

**IMPROVED PERSONAL CARE DEVICE WITH THERMAL FEEDBACK
AND OPERATING CONDITIONS DISPLAY**

FIELD OF INVENTION

The present invention relates to personal care devices and, more particularly, to personal care devices provided with heating elements and a motor driven fan. This invention also relates to hair care devices with a liquid crystal display (LCD) device. More specifically, although of course not solely limiting thereto, this invention relates to hair dryers and fan heaters with over-temperature protection and operating conditions display.

BACKGROUND OF THE INVENTION

Personal care devices with heating elements and a motor driven fan are generally used to enhance personal comfort or personal grooming.

For example, a hair care device such as a hair dryer or a hair curler with a heater and a motor driven fan provides a convenient and localized heating source with forced air circulation so that warm air can be delivered for hair care and styling within a short time. In such applications, a wide range of heating power level variation and fan-speeds is usually required in order to meet with the specific personal comfort or grooming requirements. For example, a high heating power level with a high fan-speed may be required to blow dry and style wet hair while a

low or moderate heating level and a moderate fan-speed may be required for gentle hair styling.

Similarly, in the case of fan-heaters, a high heating power and a high fan-speed will be required to expeditiously warm up a cold space while a moderate or a low heating level and fan-speed may be required to maintain a room at a relatively comfortable temperature and humidity.

To accommodate such a wide range of operating power requirements, heating elements provided in such personal care devices must be able to operate on a wide range of power output. The typical operating power ratings of such heating elements are usually in the region of a few hundred Watts to a maximum of 2,000 - 3,000 Watts.

Personal care devices of this type usually include a main housing defining an air-passageway having an air-inlet and air-outlet. The heating element is generally disposed intermediate between the air-inlet and the air-outlet so that the downstream air will be warmed or heated up before leaving the device for hair styling or other appropriate applications. These personal care devices are usually provided with user control interfacing means such as a control knob or a rocker switch with a plurality of heating level and fan-speed settings. The heating level setting is usually graduated with discrete levels and calibrated on the assumption that air will pass through the air-passageway unobstructed. Under such an assumption the heated air exiting from the nozzle or air-outlet at a pre-determined setting will be at a reasonably constant, usable, and safe temperature. However,

this is not always the case and the temperature of the heating element can be substantially elevated when the exit air passageway is blocked, for example, when the air-outlet or nozzle is placed too close near the head of the user or other blocking surfaces. This undesirable obstruction of airflow through the passageway adversely increases the temperature of the heating element because of insufficient ventilation and may result in personal injuries as well as fire hazards. Hence, it will be desirable if an improved safety protection means can be provided to such personal care devices to alleviate or avoid risks of personal injuries of fire hazards associated with the use of such devices.

Furthermore, while such personal care devices are provided with user selectable switches graduated with discrete levels for setting the operating conditions, such controlling knobs are usually in the form of rocker switches which do not provide the user with any useful and indicative operating information. Hence, it will be desirable if useful information can be conveyed to the user by means of an improved scheme and by way of improved means.

OBJECT OF THE INVENTION

Accordingly, it is an object of the present invention to provide personal care devices such as hair dryers, hair blowers, hair curlers and fan-heaters with safety and protective means are provided to alleviate the risk of personal injuries or fire hazards due to over-temperature resulting from adverse or inappropriate operation conditions of the devices.

It is another object of the present invention to provide improved personal care devices with schemes and means for visually conveying the operating conditions of the device to the user to facilitate enhanced interactive operation between the user and the device. As a minimum, it is an object of the present invention to provide improved personal care devices such as hair dryers, hair blowers, air curlers and fan-heaters as an alternative choice to the general public.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a personal care device such as a hair dryer or a fan-heater including a main housing, a motor, a motor driven fan, a heating element, controlling means, a thermal sensor, said main housing defines an air-passageway having an air-inlet and an air-outlet, said heating element is disposed intermediate between said air-inlet and said air-outlet, said thermal sensor is disposed adjacent to said air-outlet and provides temperature information to said controller, said controlling means includes memory for storing temperature information and said controlling means includes means for comparing said temperature information received from said thermal sensor with the pre-stored temperature information, said controlling means causes said heating element to reduce heating power output according to a pre-determined manner when the received temperature information corresponds to a temperature which exceeds a pre-determined threshold.

According to a second aspect of the present invention, there is provided a personal care device such as a hair dryer, a hair blower, a hair curler and a fan-

heater having display means on said main housing indicating the instantaneous operating conditions of said device.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the present invention will be explained below by way of example and with reference to the accompanying drawings, in which:

Fig. 1 is a hybrid circuit and block diagram showing the general circuit arrangements of a preferred embodiment of a hair dryer with a frontend sensing circuit connected to a micro-controller for automatic feedback control of the heating power output of the hair dryer,

Fig. 2 is a schematic circuit diagram showing an example of a general and more detailed circuit arrangement of the hair dryer of Fig. 1,

Fig. 3 is a schematic circuit diagram showing the general circuit arrangement of a second preferred embodiment of a hair dryer of the present invention including a first embodiment of electronic display means indicating the operating conditions of the hair dryer,

Fig. 4 shows a series of display variations as an example of suitable screen displays for use with the arrangement of Fig. 3,

Fig. 5 is a general circuit diagram showing another preferred embodiment of a control and display arrangement for the hair dryer of Fig. 1,

Fig. 6 shows an example of a series of graphical display layouts compatible with the display means shown in Fig. 5, and

Fig. 7 is a partially exploded view of a hair dryer illustrating the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring firstly to the hybrid circuit and block diagram of Fig. 1 and the partially exploded drawing of Fig. 7, there is shown an application in which a thermal sensing means is utilized for automatic thermal feedback to control the operation of the heating elements of a hair dryer 10 as an example. The circuit arrangement includes a thermal sensing frontend circuitry 100, a synchronization circuitry 110 for synchronizing with the alternating current supply to which the hair dryer is connected, controlling means 120 which is a micro-controller unit ("MCU") in the present example, a first heating element 130 and a second heating element 140 which are connected in parallel and individually switchable. It will become apparent from the description below that the output heating power of the hair dryer can be flexibly and sophisticatedly varied by selective turning on the individual heaters during different times of the cycles of the alternating current power supply.

Broadly speaking, a thermal sensing means, which is a negative temperature coefficient ("NTC") device 101 in this embodiment, is disposed at a convenient position to detect the instantaneous operational temperature of the hair dryer 10. The output of the thermal sensing means is connected to an input port of

the micro-controller unit 120 to provide the MCU with the sensed temperature information for appropriate action. The thermal sensing element, i.e., the NTC element in the present embodiment, is connected to a biasing circuit so that the change in the electrical characteristics of the NTC member can be transformed into an electrical signal usable by the MCU 120.

In this specific example, the NTC device is connected to a supply voltage rail (VCC). The other end of the NTC is connected to the ground via a resistor (R in Fig. 1). The output node of the NTC device, which is the node interconnecting the NTC device and the resistor R, is fed into an input port of the MCU. A capacitive means (C in Fig. 1) is connected across the resistor R as a delaying buffer to prevent over-sensitiveness to changes in the ambient temperature or transient interference. As the NTC member 101 is essentially a resistor with decreasing resistance on increasing temperature, an increase in temperature on the NTC device will result in a decrease in the resistive value. Consequently, an increase in the output voltage will be detected at the output node of the NTC device. This phenomenon provides useful control information to the MCU in determining the instantaneous downstream air temperature.

With prior calibration or tabulation of the electrical characteristics of the NTC member 101, for example, the resistance and temperature correlation of the NTC member, the relationship between the output voltage and the detected temperature can be readily determined by the MCU and utilized to prevent overheating of the hair dryer. For example, information concerning the maximum temperature threshold, and the corresponding voltage output from the NTC output

node, corresponding to a specific heating power and fan-speed setting of the hair dryer can be stored in a memory means accessible to the MCU. Once the NTC device output voltage indicates a temperature exceeding the temperature threshold, the micro-controller will send an instruction to the controlling circuitry to reduce or even turn off the heating output.

In the present specific embodiment, non-dissipative heating power output control scheme is utilized as a convenient preferred example. In this scheme, reduction in heating output is achieved by selectively activating a first heating element and/or a second heating element which are individually switchable during certain portion of the alternating current power supply. A parallel combination of two individually switchable heating elements is used in the present embodiment so that a more versatile, flexible and sophisticated heating output variation scheme can be provided.

For example, when the two heating elements are continuously turned on during the whole period of the alternating current supply, the heating power output level will be at the maximum. Reduction in heating output can be obtained by selectively turning on or off one or both of the heaters during a certain period of the alternating current supply. For example, heating power output can be reduced by actuating the first heating element during the positive half-cycles of the alternating current supply while the second heating element can be turned off only during the negative half-cycles of the power supply. Of course, the first and second heating elements can be selectively turned on during many possible

combination of actuation timing with reference to the alternating current supply cycles to achieve an overall reduced power output.

In order to reduce adverse harmonics due to selective actuation of the first and the second heating elements, it is desirable that the level of power consumption during the whole period of the alternating current supply is as even as possible since it has been observed that stronger harmonics will be generated if the technique of power chopping is utilized which will result in large power consumption differences or discontinuity during the alternating current supply cycles. Hence, it will be desirable to actuate the heating elements evenly throughout the cycles of the alternating current supplies. To fulfil this purpose, a synchronization circuit 110 with an input connecting to the alternating current supply and an output connected to the MCU 120 is provided. This synchronization circuit provides timing information of the alternating current supply so that the MCU can determine the appropriate actuation timing of the heating elements at or near zero-crossing point of the alternating current supply or other appropriate points to reduce harmonics and alleviate other undesirable effects. In this preferred embodiment, triacs are used and the synchronization circuit provides useful firing and time information to actuate the triacs.

In the present specific embodiment, power reduction by selectively power chopping or selectively turning on and off the heating elements at appropriate times provides a non-dissipative scheme of power reduction and the heating element actuation timing control is important to reduce adverse harmonics. Of course, dissipative schemes of heating power reduction can also be used. In

dissipative heating power reduction schemes, a dissipative element, such as a load resistor, is generally connected in series with a heating element or a combination of heating elements so that the extra or redundant electrical energy is wasted through the dissipative element. As the problem of adverse harmonics is not usually critical in such dissipative schemes, less stringent heating element actuation timing schemes are required and the synchronization circuitry may not be required.

Referring to Fig. 2, a more detailed circuitry diagram embodying the circuitry of Fig. 1 is shown. It will be noted that the thermal sensing circuitry 100, the first 130 and the second 140 heating elements and the synchronization circuitry 110 are connected to the MCU 120. In addition, user controlling interfacing means, including a fan-speed setting knob 150 and a heating level selecting knob 160, is also provided. Furthermore, display means 170 indicating the operating conditions of the hair dryer are connected to the output ports of the MCU 120 so that the appropriate operating conditions can be transmitted from the MCU for showing on the display means. A direct current (DC) motor 180 is provided to provide forced air movement for delivering air from the hair dryer and a rectifying bridge is provided to generate the necessary direct current supply. An additional set of heating element 190 is further provided between the alternating current supply and the rectifying bridge to accommodate or absorb the voltage supply differences between the rated input voltage of the rectifier and the output of the alternating current supply.

Turning now to the operation of the hair dryer by referring to the hair dryer of Fig. 7, it will be noted that the hair dryer 10 includes a main housing 11 having a

barrel 12 and a handle 13. A first heating element 130, a second heating element 140, a motor and a motor driven fan 181 are generally disposed inside the barrel 12. For user convenience, the user controlling interfacing means including the fan-speed control knob and the heating level setting knob are preferably disposed on the outside of the handle portion. The barrel defines an up-stream air-inlet 14 near the handle portion and a downstream air-outlet 15 at the other end. The heating elements are preferably disposed intermediate between the air-inlet 14 and the air-outlet 15. The thermal sensing means, or the NTC element 101 in the present embodiment, is disposed near the air-outlet 15 since, under normal operation, the exiting air will have an elevated temperature and the temperature at this position will build up rapidly if adverse operating conditions are encountered. When the heating power control knob is set a pre-determined level with a pre-determined fan-speed, the warm air exiting from the air-outlet would not normally exceed the temperature threshold under normal operation. Such a temperature threshold can usually be represented by an electrical parameter characteristic of the thermal sensing circuit. In the present embodiment, this temperature threshold is represented by the maximum voltage output at the NTC output node 102.

When the warm- or hot- air generating hair dryer is pushed towards a blocking surface, the temperature of the heating elements will be elevated as a result of insufficient air ventilation or insufficient radiation. Continued blocking may cause the heating element to become red hot and cause personal injuries and fire hazards. In the present embodiment, the micro-controller 120 will appropriately reduce the heating output to alleviate such risks and hazards upon

detection of a signal indicating over-temperature. The normal heating output may be resumed, if on a subsequent MCU check, the thermal sensor output voltage is restored to a safe level. As explained before, the heating power output can be reduced by dissipative or non-dissipative schemes although non-dissipative schemes are preferred for the preservation of energy and environmental protection. Of course this thermal feedback control topology can be utilized in both the dissipative and non-dissipative schemes.

Referring to Fig. 3 in which a second control and display circuitry of a preferred embodiment of the hair dryer is shown, the hair dryer circuit includes a motor 280 with a parallelly connected switchable shunt resistor controllable by the switch SW2 250 for speed variation and a switchable ionising circuitry providing ionised warm air to the hair for styling. In addition, a heater level control switch 260 SW1 switchable to a plurality of discrete heating power level settings are also shown. The operating conditions of the switch SW2 280, the ionising circuit 261, and the heating level SW1 switch are connected to the input ports of a MCU. The output of the MCU is connected to a display means 270 for displaying the operating conditions of the hair dryer.

For example, when the shunting switch SW2 250 is closed, corresponding to a lower motor speed, the terminal of SW2 will be pulled high and the input port PB3 of the MCU 220 will detect a low signal because of the inverted circuit connected between the input port PB3 and the switch SW2 250. Similarly, the MCU 220 can detect whether the ionising circuitry is in operation by detecting whether the serial switch "IONIC SW" 262 is closed or opened. When IONIC SW

262 is closed, this terminal is at a high potential and the input port PB4 of the MCU 220 will detect a low signal. Similarly, when the heating power level selector switch SW1 260 is set to the "high" setting corresponding to a high power output, the input port PB1 of the MCU 220 will detect a low signal while the other input port PB0 will remain high. On the other hand, when the switch SW1 260 is set to the "low" setting, the input at PB0 of the MCU will be pulled low and the input port PB1 will remain high. Thus, by scanning the conditions of the input ports PB0 and PB1, the MCU can decide the instantaneous heating power level setting and transmit information concerning the operating condition to the display means. The display means can be, for example, a LCD or other appropriate displays, includes a plurality of input nodes for connecting to the output nodes of the MCU.

By appropriate configuration or programming of the MCU, the operating conditions or parameters of the hair dryer as detected and monitored at the various input ports of the MCU will be converted into the corresponding control signals at the output ports for showing on the display means. The display samples shown in Fig. 4 represent a series of possible information display which can be shown on the display means for reflecting the operating conditions of the hair dryer.

For example, this preferred hair dryer has two speed settings and two heating power level settings with an additional "cool shot" for blowing only cool air, making a total of five different combination settings. The operating conditions of the hair dryer can then be shown in the display means.

In the preferred example of the display means and referring to the left-most column of the graphical displays, the first row of display corresponds to the operating setting number with the range of 1 to 5, the second row indicates the present heating power level setting in numerical form showing the wattage and the third row indicates whether the negative ion emission circuitry is in operation. On the right side, an 8-bar indicator is provided to indicate the temperature of the air exiting from the hair dryer. Usually, more lit bars will mean a higher temperature and when all the 8 bars are lit, it means the hair dryer is operating at its highest operating temperature.

Referring to the second column of graphical representations of Fig. 4, in this configuration, most of the display variations have the same meaning as that above except that the 8-level bar indicator is now used to indicate the fan-speed of the hair dryer. As there are only two power settings, the 8-level bar indicator is split into two display regions comprising 4 bars each. When the hair dryer is operating at the high fan-speed, all the 8 bar levels are lit. On the other hand, when the hair dryer is operating at a low fan-speed, only the four lower bars are lit. Thus, it will be appreciated that the display means can be flexibly arranged to provide the desirable information for the benefit of the consumers. In addition to the functional parameters to be displayed, other information, for example, the trade mark, logo, or other proprietary signs 500 of the manufacturer can also be displayed on the same display means or on the main housing of the hair dryer whether by LCD, LED or other appropriate display means.

Referring to Figs. 5 and 6, there is shown a hair dryer with a second preferred embodiment of control and display means 370. In this hair dryer, the usual essential features of hair dryers are similarly provided and will not be discussed in detail. This hair dryer includes a plurality of progressive or gradual control switches SW1-SW6 separating into three groups, namely, SW1 and SW2, SW3 and SW4, SW5 and SW6. For example, the switches 360 SW1 and SW2 correspond to the heating element control, SW3 and SW4 350 correspond to the fan-speed control and SW5-SW6 361 correspond to the ionizer control. When SW1 is pressed, the MCU will progressively increase the heating power output until SW1 is released. On the other hand, when SW2 is depressed, the MCU will control the heating elements to reduce the heating power output until SW2 is released. When neither SW1 nor SW2 is depressed, the hair dryer will continue operating in its present state. Likewise, when SW3 is depressed, the MCU will increase the fan-speed until SW3 is released or when maximum speed has been reached. Similarly, when SW4 is depressed, the MCU will cause the fan-speed to decrease until the motor stops or until the switch is released. The ionising control switches SW5 and SW6 work generally under the same principles.

In this preferred example, the possible depression of the control switches is by the formation of a matrix comprising the input ports 20 - 24 of the MCU with port 20 corresponding to the control of the heating element, port 21 corresponding to the fan-speed control and port 22 corresponding specifically to the ionizers control. Similarly, port 24 of the MCU corresponds to an indication of upward adjustment and port 23 indicates downward adjustments. Of course, other

arrangements are as possible. By using a matrix form of combination control, a user's request for change of operating conditions can be constantly monitored and entertained. In this preferred embodiment, a different form of display is provided. The display in the present embodiment includes a LCD display means with the speed and temperature presented in two separate bar-indicators plus an ionizer triggering sign. By connecting the LCD display means to the MCU, the speed and temperature display bars can provide a multi-level indicator corresponding to the signal provided by the MCU corresponding to the detected operating conditions.

The three columns of display shown in Fig. 6 shows some possible variations of the LCD information displays arrayed in column order speed, temperature and ionising indication.

While the present invention has been explained by reference to the preferred embodiments described above, it will be appreciated that the embodiments are only examples provided to illustrate the present invention and are not meant to be restrictive on the scope and spirit of the present invention. This invention should be determined from the general principles and spirit of the invention as described above. In particular, variations or modifications which are obvious or trivial to persons skilled in the art, as well as improvements made on the basis of the present invention, should be considered as falling within the scope and boundary of the present invention. Furthermore, while the present invention has been explained by reference to a hair dryer with non-dissipative power reduction scheme, it should be appreciated that the invention can apply, whether

with or without modification, to other hair dryers and fan heaters irrespective of the mode of power reduction schemes.